Space Weather Technical Forecast

Issued on Sunday, 05 November 2023 at 01:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/G2 Minor/Moderate geomagnetic storms expected and chance of G3/Strong storming day 1-2 (05-06 Nov) due to CME arrival. Chance of M-Class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with a number of low-level C-class flares observed. There are eight sunspot regions on the visible disc. The largest is AR3477 in the southeast disc, dominated by a large leader spot, however this remains mostly stable and otherwise simple. AR3480, also in the southwest disc is comprised of a smaller string of spots, each with penumbra. A mixed polarity region near the AR3480 trailer is suggestive of slightly increased complexity in comparison, although this region also appears stable. The only notable growth has been in AR3479, a small region in the northwest. No Earth-directed CMEs have been observed, with the large CME to the northwest assessed as missing. However, there are a large number of filaments currently on the Earth-facing disc, and these will need monitoring for any further potential lifts.

Solar Wind / Geomagnetic Activity: Solar winds at L1, showed the arrival of a CME, likely from a filament eruption on 31 Oct, with some potential that this included the glancing CME that is currently expected on 05 Nov. The speed persisted at background, below 350 km/s. Density was initially below average, then showed a small discontinuity at 04/1122 UTC before rising to briefly be well above average, peaking at 53ppcc at 04/1643 UTC. Density then persisted above average until after 04/2200 UTC. Total interplanetary magnetic field (IMF) strength, Bt, also rose during a similar period, from initially weak (below 6nT) to peak Strong at near 18nT around 04/1745 UTC. The north-south component, Bz, was predominately negative (southward) orientated, and moderately negative for much of the time between 04/1600-2200 UTC, with minimum -15nT. This rotated positive (northward) after 04/2200 UTC to peak 10nT. Phi angle was initially positive (away from the Sun), but negative (towards the Sun) at times after 04/0740 UTC, and neutral, veering negative from 04/1700 UTC. Geomagnetic activity was Quiet (Kp1-2) until 04/1800UTC, then G1 Minor Storm 04/1800-2100 UTC and Active 04/2100-0000UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux eased from very slightly above base line due to the filament eruption on 03 Nov, to be at background. GOES16 high energy (greater than 2MeV) electron flux was predominately High for much of 04 Nov, and increased to peak 9840 pfu at 04/1700 UTC. A sudden drop-out followed, falling to background by 04/1905 UTC. The associated 24-hour fluence has been above the Active (1e8 integrated pfu) threshold throughout, but with a declining trend since the drop out. The observed fluence at 05/0000 UTC was 1.65e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate solar activity is expected, with chance of isolated M-class flares.

Solar Wind / Geomagnetic Activity: There are two further potential CME arrivals, both on day 1 (05 Nov). The first is low confidence, from the coronal dimming event on 02 Nov, with some possibility it may have already arrived. The second is the CME from the large filament eruption on 03 Nov. This is currently forecast to arrive 05/1800 UTC, with ongoing effects expected on 06 Nov. Otherwise, onset of the fast winds from coronal hole 67 are also expected to bring a further

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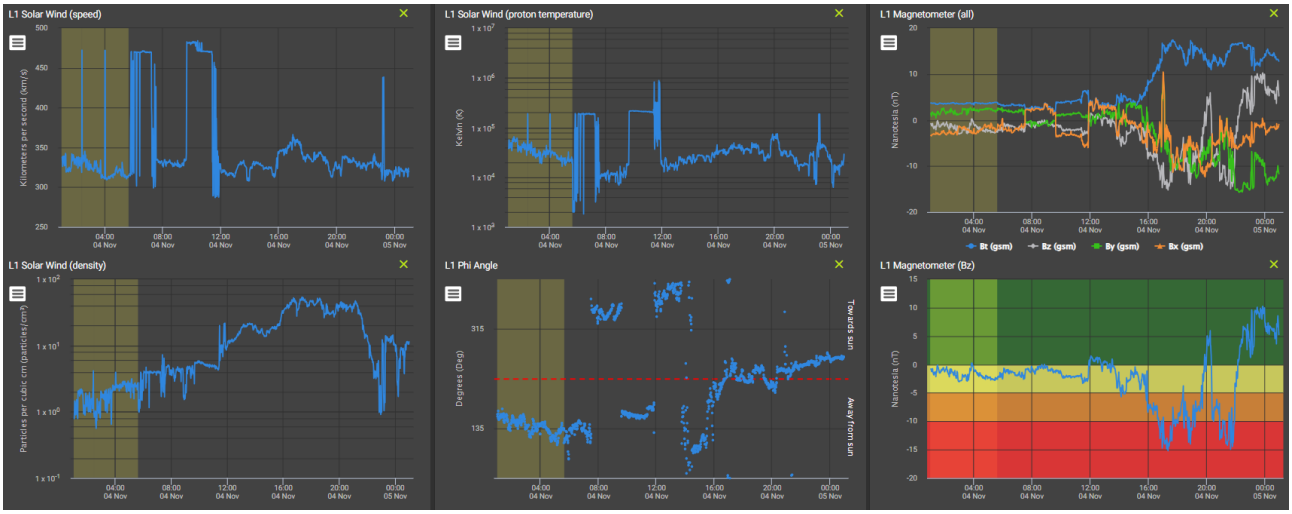
increase to solar wind speeds through day 3 and into day 4 (07-08 Nov). Geomagnetic activity is forecast to initially be Quiet to Active, as current CME enhancement eases. Further CME arrivals then likely increase activity, with a chance of G1 Minor Storms from the first CME, increasing to Active to G2 Moderate Storms, with a chance of G3 Strong Storms from the second. These most likely late day 1 and early day 2 (05-06 Nov), with solar wind speeds also rising to around 600km/s. Activity and winds easing later day 2 and into day 3 (06-07 Nov) to be Quiet to Unsettled, with Active intervals possible. However, onset of fast winds from CH67 will then bring a chance of further Active spells, with a slight chance G1 Minor storm intervals and winds again increasing to around 600km/s.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to persist at background levels. High energy electron flux (greater than 2MeV) is expected to remain mostly at background day 1 and into day 2 (05 Nov-06 Nov) due to the likelihood of ongoing CME enhancements. Some recovery is then likely, perhaps to High, however this is low confidence due to uncertainty with the impact of the CMEs and also the potential fast wind enhancement day 3-4 from CH67/-. The associated 24 hour fluence is expected to soon fall below the Active threshold, and likely persist at this level. There is then a slight chance of rising above later in the period.

Figure 1a: L1 solar winds, showing CME arrival (top) and SWPC Kp (bottom)



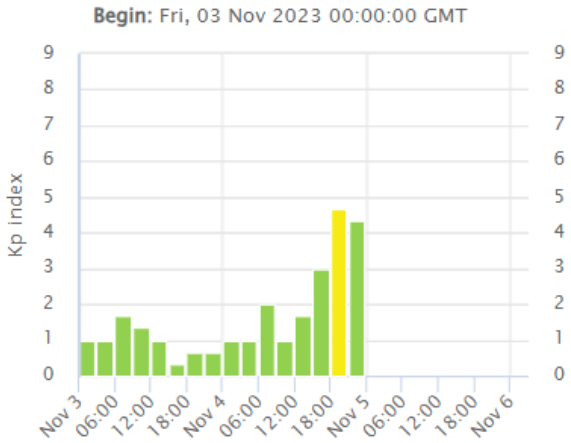


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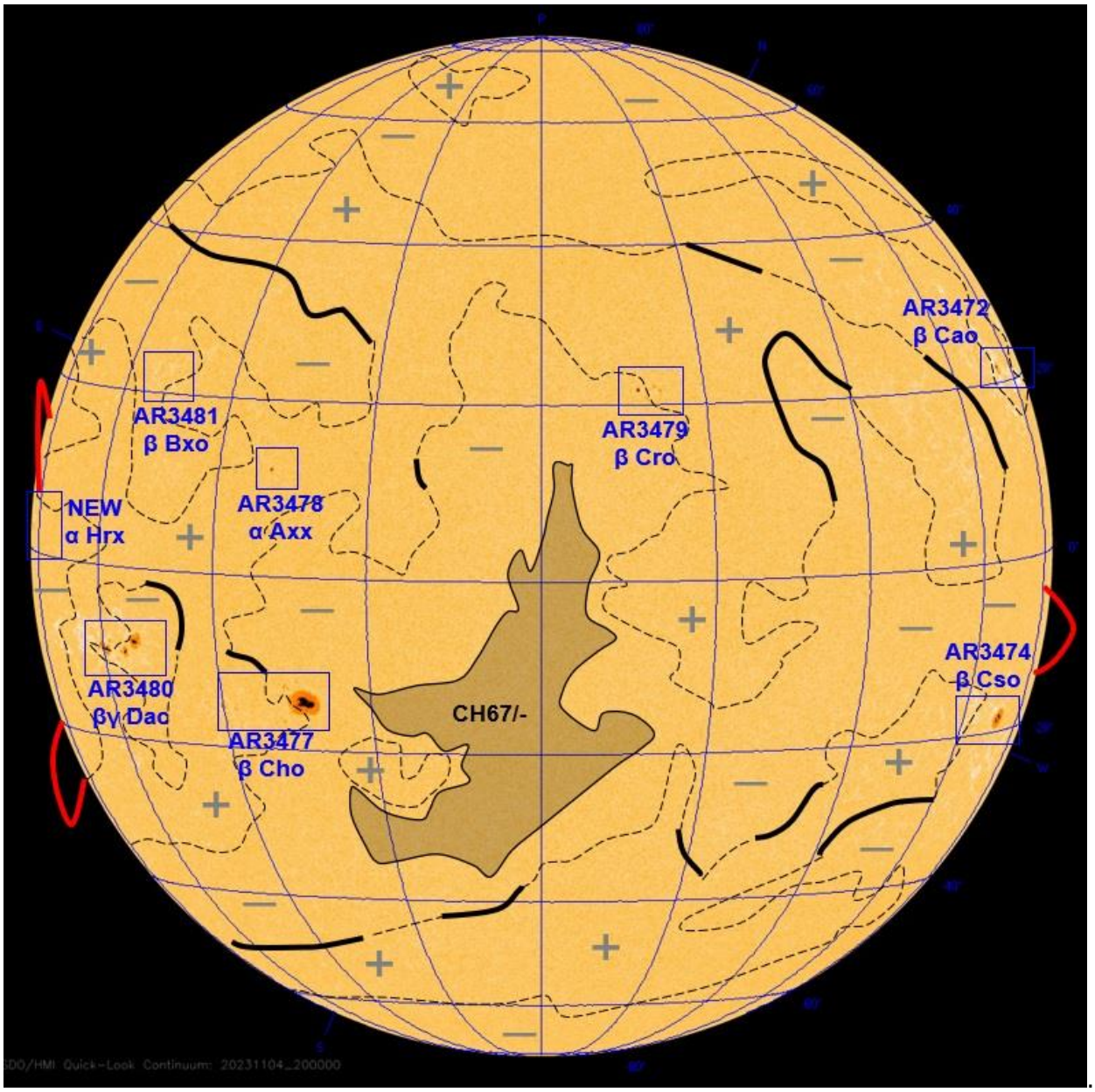
Figure 1b: Solar Analysis Valid 05/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two Earth-directed CMEs, although the first is low confidence. This is from a coronal dimming event early on 02 Nov on the northeast disk, with subsequent filament channel visible in SDO aia-304, and may give Earth a glancing blow early on day 1 (05 Nov) with the bulk of the CME missing behind and to the north. Furthermore, there is some potential that this CME may have already arrived and been either part of, or the cause of the enhancement on 04 Nov.

A more significant CME was observed from a large filament eruption on the northwest disc 03/0430 UTC. This produced a partial halo CME, with forecast arrival later day 1 (05 Nov). Due to the nature of the CME, from a large dense filament, the strongest geomagnetic activity is likely from the subsequent magnetic cloud, post arrival, continuing through day 2 (06 Nov)

Solar wind are currently at background speeds, despite a recent CME enhancement, and these speeds are likely to persist until the arrival of the CMEs above. These could then potentially enhance speeds to around 500-600km/s, especially with the 2nd arrival later day 1 (05 Nov), before gradually easing later day 2 and into day 3 (06-07 Nov). There is then the potential for a further enhancement from the arrival of the fast wind of CH67/- day 3, as shown by enlil, potentially peaking around 600km/s, with fast winds persisting into day 4 (08 Nov).

Geomagnetic activity is expected to be Quiet to Active at first, as current CME enhancement eases. Further CME arrivals are then likely to increase activity, with a chance of G1 Minor Storms from the first CME, increasing to Active to G2 Moderate Storms, with a chance of G3 Strong Storms from the second. These most likely late day 1 and early day 2 (05-06 Nov). Activity easing later day 2 and into day 3 (06-07 Nov) to be Quiet to Unsettled, with Active intervals possible. Onset of fast winds from CH67 will then bring a chance of further Active spells, with a slight chance G1 Minor storm intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	80	70	20	10
Strong	G3	No	20	30	1	1
Severe	G4	No	5	5	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
02/0915	Partial	Coronal dimming/filament	NE	648 km/s	05/0500	Glancing impact. Low confidence.
03/1008	Partial	Large filament	NW	730 km/s	05/1800	Moderate confidence

Figure 2: Enlil and Ensemble, showing CME arrivals (including 31 Oct CME, which has been reentered to assess likelihood of current conditions being from that eruption)

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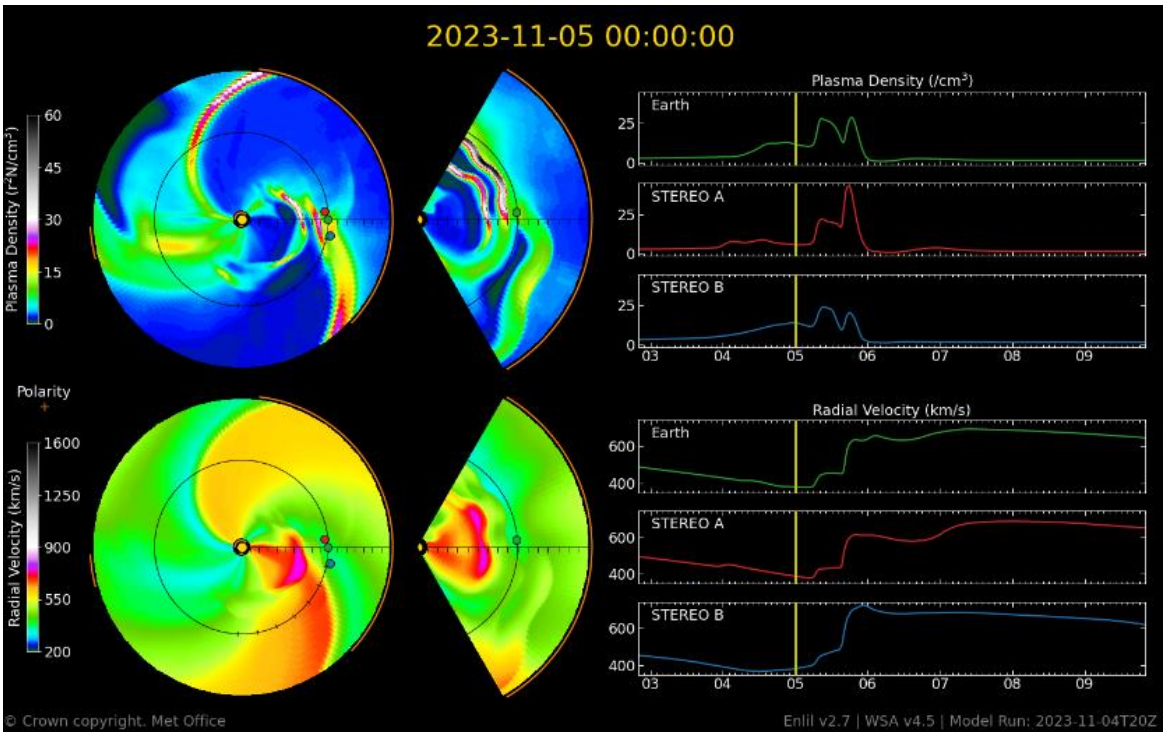

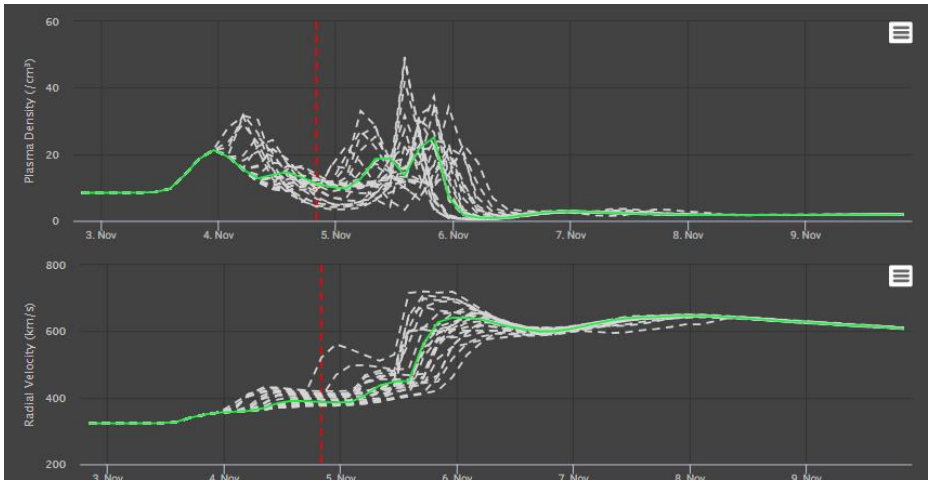

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Radio Blackouts - X-Ray Flares:

Low Activity is expected with a chance of increasing to Moderate due to isolated M-flares.

There are eight sunspot regions on the disc. AR3477 in the southeast is the largest region, dominated by a large and mature leader spot but with little sign of ongoing development. AR3480 is perhaps the most complex region, comprising of a string of smaller spots all with clear penumbra, including a very small mixed polarity region around its trailer resulting in a beta-gamma configuration, although the viewing angle is currently oblique leading to low confidence. However, any development of this region remains slow.

The other regions on the disc are currently smaller and simpler, with a lower chance of notable flares without further development. However some growth is observed in AR3479 in the north-centre disc.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3a: GOES-16/18 X-ray flux

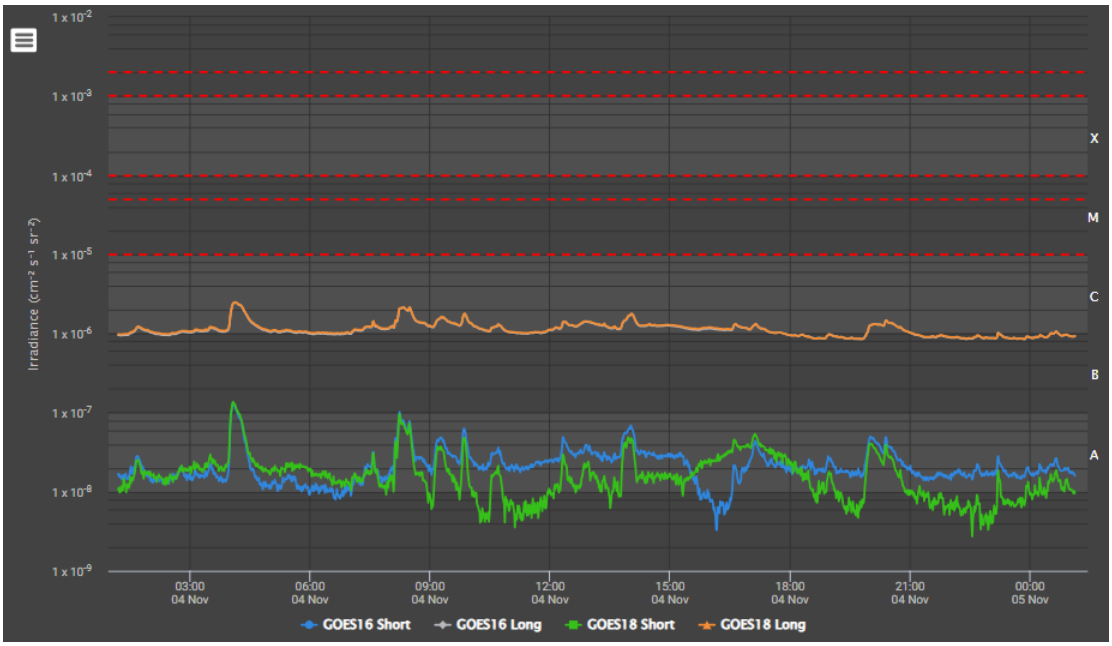

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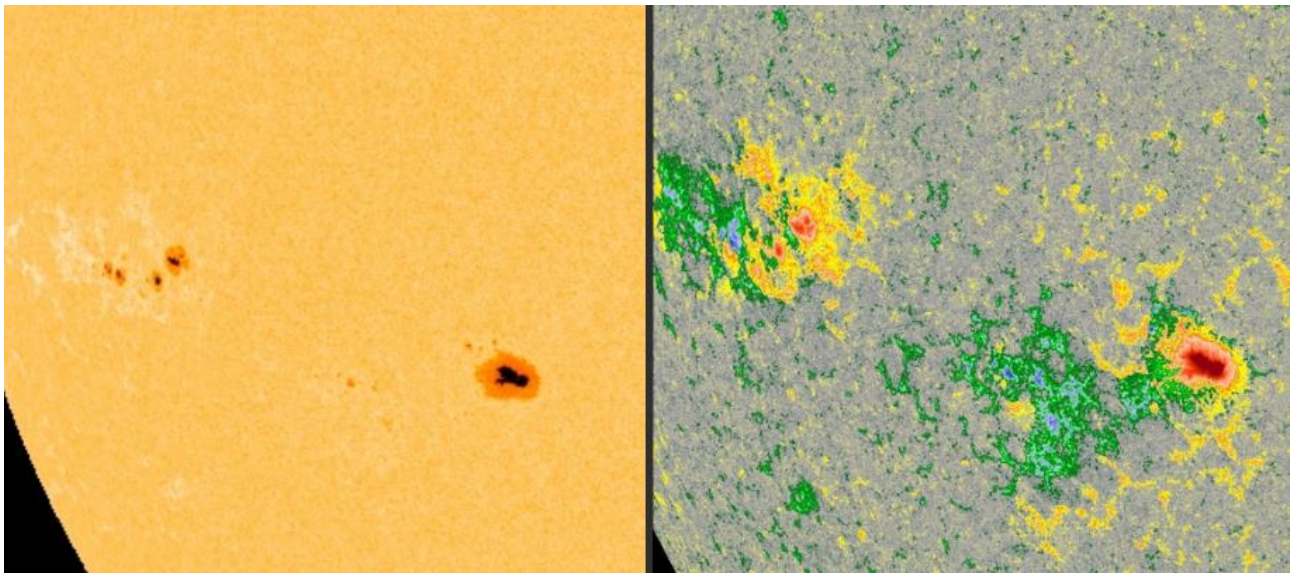
Figure 3b: SDO imagery of SE disc with AR3480 and AR3477 (intensitygram left, magnetogram right)



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at mainly background levels. The main source of any enhancement is likely to be from any filament eruptions or from any more significant flares. These are most likely to effect the Earth if originating from the western disc, with a slightly increased risk by the end of the period as the larger and more complex sunspots traverse into the hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as measured by GOES16 has dropped out due to the recent CME enhancement. Further CME arrivals are likely to disrupt the Van Allen Belts at GEO, resulting in the observed electron flux to persist at most background day 1 (05 Nov), perhaps briefly recovering to Moderate. Once CME enhancement eases the electron flux forecast becomes very low confidence, with the potential for rising to Moderate to High. However, any further enhancement from the onset of the fast winds of CH67/- also brings the potential for further drop out days 3-4 (07-08 Nov), before recovering.

The associated high energy 24 hour electron fluence is currently Active (above 1e8 pfu), but expected to soon fall below on day 1 (05 Nov) due to recent drop out in flux. Further enhancement is low confidence, due to the uncertainties around how the flux will respond to any CME or coronal hole enhancement. These also lead to very low confidence in the current REFM forecast.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	20	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: GOES-16 >2MeV Electron flux and Fluence with REFM

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